MBL

Biological Disco n Woo s Hole

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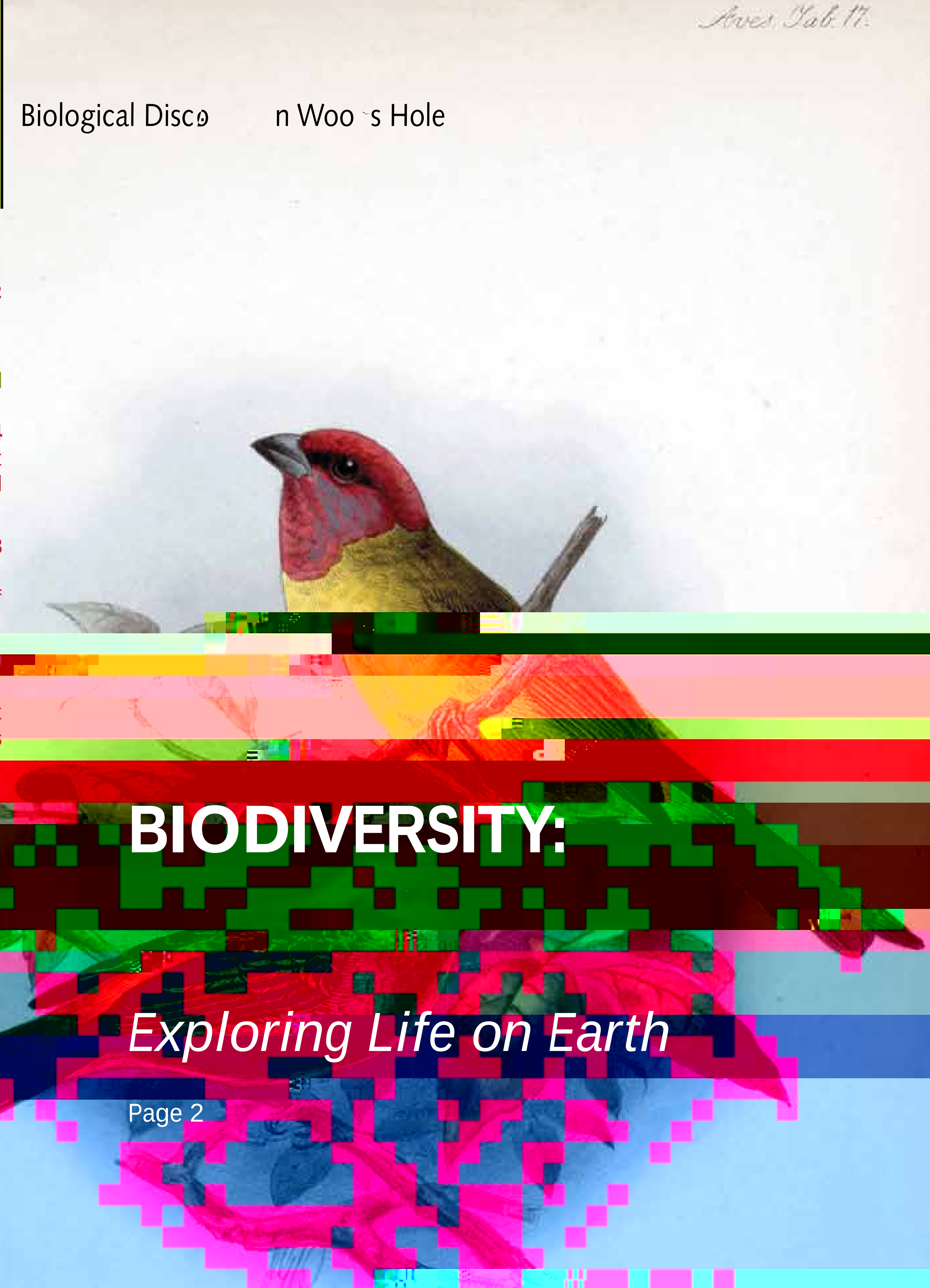
IN THIS ISSUE



BIODIVERSITY:

Exploring Life on Earth

Page 2

Dear Friends,

In February, a group of MBL trustees, overseers, and friends took a memorable "eco-expedition" by safari through East Africa. For most of us, the most exciting aspect was seeing the megafauna – giraffes, zebras, lions, warthogs, wildebeests, rhinoceroses—roaming wild in a pristine landscape. Except in tropical Asia, these large, charismatic animals aren't found anywhere else on the planet—not in the Americas, Europe, Australia, or New Zealand.

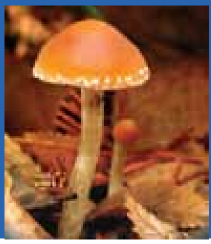
Why did they disappear? The reasons are debated, but there is good evidence that overkill by prehistoric humans caused major losses. Unfortunately, the near-extinction of these species 10,000 to 50,000 years ago is not the end of the story. It is generally agreed that the Earth is facing another biodiversity crisis in this century, with extinctions largely driven by destruction of habitat.

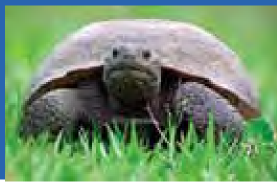
Species loss has come to the forefront of global concerns, as evidenced by such efforts as the United Nations' Decade on Biodiversity (2011-2020). But to effectively preserve biodiversity, we need to understand what we have to protect. The good news is that our ability to describe and understand existing biodiversity, and to discover new species, is rapidly advancing. At the MBL, we are committed to these efforts, and we are pioneering the technologies they require.

Departments

Biodiversity is a never-ending adventure; there is always something new to discover," says Bob Corrigan of the Encyclopedia

e on Earth





to Harvard biodiversity expert E.O. Wilson. We don’t exactly know what we are losing, but it is surely thousands of species a year. Besides the negative impact that biodiversity loss has on ecosystem stability, with each extinction we lose the opportunity to discover a new material, a new molecule, or a new design that could transform medicine, environmental engineering, or industry.

More importantly, all species are linked through our common evolutionary roots. The better we understand our co-habitants on Earth, the better we understand ourselves and the biosphere we share.

The new features took off immediately: EOL users created more than 1,000 collections within the first month. “Someone made a definitive list of state flowers. Someone else made a list of endangered and threatened species of Costa Rica, which never before existed on the Web,” Corrigan says. Now people want to share their collections via Twitter and Facebook, another new EOL capability.

Through a collaboration with developers at the Library of Alexandria in Egypt, version 2 also rendered the EOL translatable into any language. To achieve this, Wilson’s group audited the EOL’s open-source code, located all the text strings sprinkled around in the code, and centralized them into one file. The Library of Alexandria team could then translate the interface into Arabic. Next, Wilson’s team had to make sure the EOL actually looked good in different languages. This meant redesigning the species pages from the ground up to accommodate languages that are read right to left, such as Arabic, or translations that are twice as long as the original English. Wilson’s team has since integrated Spanish content into the site, which is proving to be very popular, and several other languages will be coming online soon.

While refining version 2, Wilson and Corrigan are presently focused on strategies to bring more users to the site, including improving its visibility in Google and other search engines. And they are continually thinking about “what’s next” in order to realize the great potential of the EOL.

“The question most commonly asked by EOL users is, ‘What is in my backyard?’” Wilson says. “Unfortunately, that’s a pretty hard question to answer. But it would be very useful if EOL could give them a list of the 100 butterflies or 100 birds or 100 insects they are most likely to see. People are hungry for that functionality.”

To get there, the EOL needs to incorporate maps of species distributions, an ongoing and challenging goal. The EOL is partnering with other groups working in this area, including the Global Biodiversity Information Facility and the Atlas of Living Australia. Distribution maps will also bring the EOL much closer to one of its overarching goals: to assist in the preservation of biodiversity.

And then there is the desire, voiced since the EOL was first envisioned, for the site to aid in the discovery of new species. That’s not an easy problem to address, either.

“Let’s say you take a picture of something and you want to know if it’s a new species,” Wilson says. “There is a precursor to that: You take a picture of something and you want to know what it is.” For the EOL to help you, its content needs to be “computable,” so if you search on a descriptive term such as “blue bird,” the EOL can pull up all the blue birds referenced in its gigantic database.

But right now, the EOL has thousands of photos that someone may have briefly described, but the computer can’t tell what is pictured. Similarly, the computer can locate organisms by name, but it “has no insight into what the text says,” Wilson explains. However, “One of the interesting things about the (species) descriptions that come into the EOL is they are more parsable, or computable, than most data, if you apply the right technologies. The MBL Center for Library and Informatics has begun developing those technologies, and that is an important direction we want to go in,” he says. “Being able to understand the historical literature, from a computer standpoint, is a very significant biodiversity informatics problem right now, and it will require a combination of computer automation and effective human review.”

According to Corrigan, the Biodiversity Informatics Group is more than up to the heady challenges of reaching the EOL’s goal of “Global Access to Knowledge About Life on Earth.” “It really is a wonderful combination of deep thinkers and focused doers,” he says. “They present cutting-edge bioinformatics best practices and terrific solutions. With the help of the team at MBL, we are building the EOL for the millions, and we are building it to last.” s—DK

Comprehensive Mission to Document Earth’s Species is Planned

A global mission to describe 10 million

Walk This Way: Scientists and MBL Physiology Course Students Describe How a Motor Protein “Steps Out”

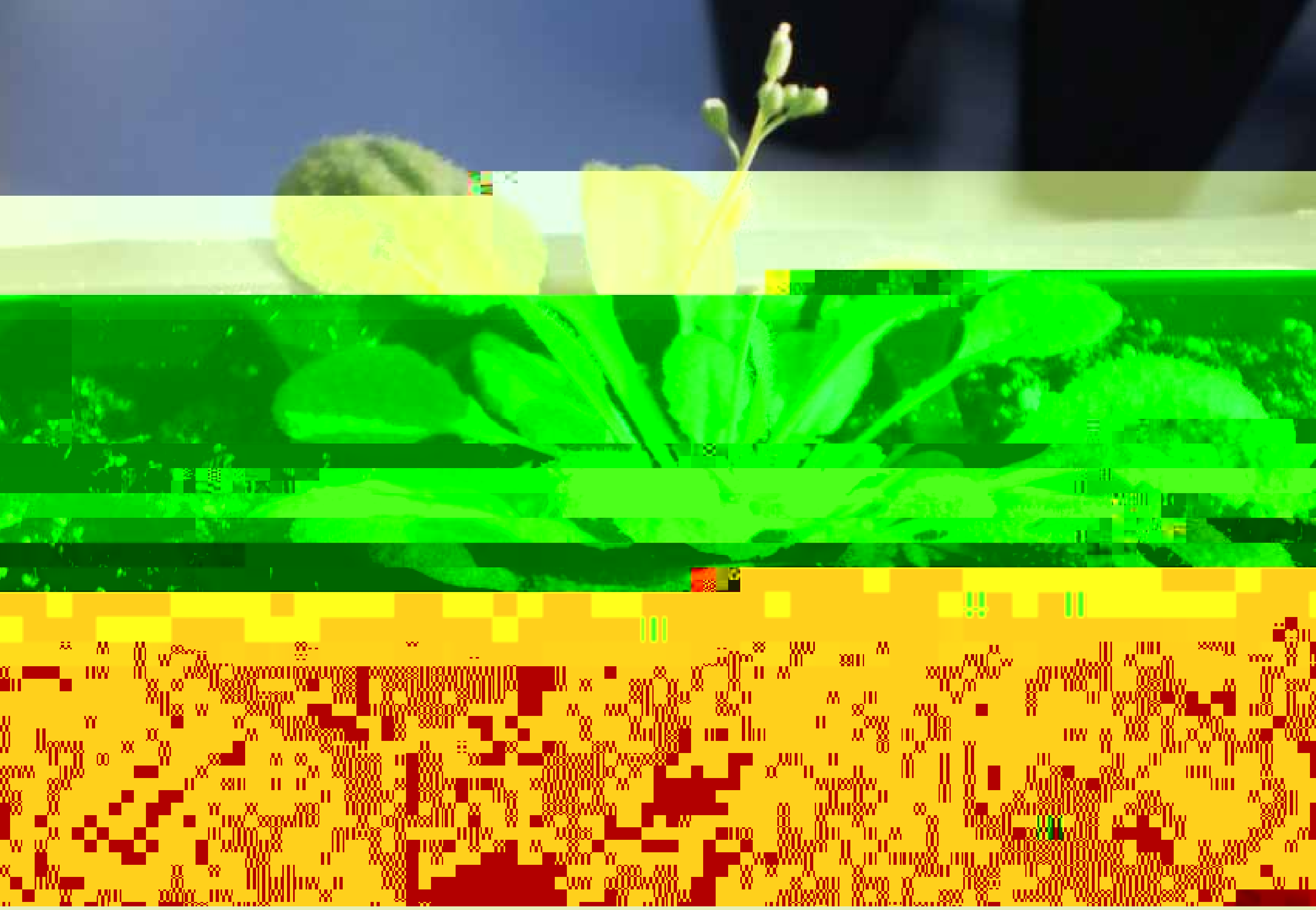
MBL scientists and students have discovered the unique “drunken sailor” gait of dynein, a protein that is critical for the function of every cell in the body and whose malfunction has been associated with neurodegenerative disorders such as Lou Gehrig’s disease and Parkinson’s disease. Samara Reck-Peterson of Harvard Medical School led the research, which was partially conducted in the 2007 MBL Physiology Course by students Elizabeth Villa of the Max Planck Institute of Biochemistry and David Wu of UCLA’s Geffen School of Medicine. Dynein is one of three types of “motor proteins”: tiny molecular machines that constantly shuttle materials needed to keep cells alive, allow cells to move and divide, and enable cells to talk to their neighbors. All three types of motor protein (dynein, myosin, and kinesin) are “two-footed” and use the energy from breaking chemical bonds to generate movement. “The myosin and kinesin motors work by walking more or less like we do: one foot in front of the other in a straight line,” says Reck-Peterson. “We have discovered that the third motor model, dynein, appears to be different. Its two feet are at times uncoordinated and often veer from side-to-side (think drunken sailor). This mode of walking makes the dynein motor unique and may allow it to navigate obstacles while performing its transport functions in cells. Interestingly, our data also suggest that the dynein motor becomes more coordinated when it is hauling something large, implying that the motor can become more efficient when necessary.” (*Nat. Struct. Mol. Biol*. 19: 193-200, 2012). s

MBL and Partners to Study Climate Change in Falmouth Salt Marshes

Ecosystems Center assistant scientist Jim Tang and his partners have been awarded a $1.3 million grant from the National Estuarine Research Reserve System to examine carbon and nitrogen cycles in salt marshes in Waquoit Bay, Falmouth, Mass., and to determine how those cycles are impacted by, and feed back to, climate change. Tang and colleagues from the Waquoit Bay National Estuarine Research Reserve, U.S. Geological Survey, and University of Rhode Island will quantify how much greenhouse gas is stored in and emitted from coastal wetlands, and how the presence of nitrogen changes this balance. Greenhouse gases contribute to global warming by trapping heat in the atmosphere. While it is well known that forests store large amounts of carbon, thus reducing global warming, there is new focus on equivalent stores of so-called “Blue Carbon” in coastal ecosystems. Preliminary work has shown that when nitrogen is present (as it is in most coastal areas) salt marshes actually become sources of greenhouse gases, rather than sinks. Tang will use novel laser-based technology to develop a new system for measuring greenhouse gas emissions from salt marshes directly in the field to dramatically improve the accuracy and frequency of greenhouse gas measurement. In addition to producing “pure” science, the project will link researchers with end-users, who will apply the science to

In a Brainless Marine Worm, Whitman Investigators Find Parts of the Developmental “Scaffold” for the Vertebrate Brain

The evolutionary origin of the vertebrate brain is a mystery, because nothing anatomically like it has been found in invertebrates. Yet a clue to its origins was recently discovered by Whitman Investigators Ariel Pani of University of Chicago, Chris Lowe of Stanford University, and their colleagues. The team discovered some of the genetic processes that regulate vertebrate brain development in, surprisingly, the acorn worm (*Saccoglossus kowalevskii*), a brainless, burrowing marine invertebrate whose lineage diverged from vertebrates more than 500 million years ago. The scientists found three “signaling centers” in the acorn worm embryo that are also present in the vertebrate embryo. In vertebrates, Pani says, these signaling centers are major components of a gene expression program “that sets up the foundation of how the brain develops.” In acorn worms, they direct the formation of the embryonic body plan. These signaling centers are not present in sea squirts and lancelets, vertebrates’ closest living evolutionary relatives, so it was unexpected to find them in the acorn worm, a more distantly related hemichordate. “The lancelet and sea squirts will still be the first animals we will look at if we want to understand vertebrate evolution,” says Pani. “But if we find differences, we now know it is important to look at anatomically divergent animals, where you wouldn’t have previously expected to find compelling similarities. I think this principle applies broadly to understanding animal evolution.” (*Nature* 483: 289-294, 2012). s



hough invisible to the naked eye, microbes are everywhere. They thrive in familiar environments like farm soils and inside the human body, but also in the harsh conditions of geysers and glaciers. Microbes are essential drivers of all ecosystems, affecting processes from decomposition to vegetation growth to climate change. Yet little is known about how microbial communities form, or the ecological rules that govern their maintenance.

"When we go out in nature and take a microbe sample, we're essentially taking a snapshot of that community at a particular point in space and time," says Sheri Simmons, a scientist at the Josephine Bay

“*Arabidopsis* has many leaves that are quite similar to each other,” Simmons says. “When we sample individual leaves, we are looking at microbial communities that started from the same initial point, but they might have

Life, Literature, and the Pursuit of Global Access

THE BIODIVERSITY HERITAGE LIBRARY

DIGITIZES A WEALTH OF NATURAL HISTORY KNOWLEDGE

There are millions of unique species on Earth, 1.9 million of which have been scientifically identified. What scientists have discovered about these species over centuries fills many millions of pages of literature. Now, one by one, those pages are being scanned and uploaded onto the Biodiversity Heritage Library (BHL) website.

“For many years, there has been a demand from researchers to digitize biodiversity literature,” says Tom Garnett, a Smithsonian Institution librarian and program director of the BHL. “You can’t do new research without having old literature available.”

Much of that old literature is now on the BHL website. The searchable, digital collection ranges from 600-year-old, handwritten Latin texts, to lavishly illustrated books on botany from the 1800s, to papers published by today’s scientists. Almost 40 million pages have been uploaded into the BHL since it was founded in 2005, and, despite legal and practical obstacles, new material is continuously added.

The MBLWHOI Library, one of the original 10 libraries involved in the BHL, has contributed scans of thousands of books.

“We were one of the first libraries that got this up and running,” says Cathy Norton, MBLWHOI Library Scholar and chairman of the BHL. “We started scanning immediately. I think at one point we had scanned half of the things that were in the BHL.”

The BHL is now global, with more than 40 libraries in the United States, Europe, South America, Egypt, Australia and China. Each library contributes a unique collection of biodiversity texts.

To facilitate the process, the BHL cooperates with the Internet Archive, a project to build a comprehensive online library. As part of this effort, the Internet Archive has established several scanning centers in the United States.

“We would load 500 books on trucks and send them to the Boston Public Library,” Norton says. “I like to say they went to the book spa, where they got cleaned and scanned by Internet Archive employees. Then they’d come back and we’d send up another 500.”

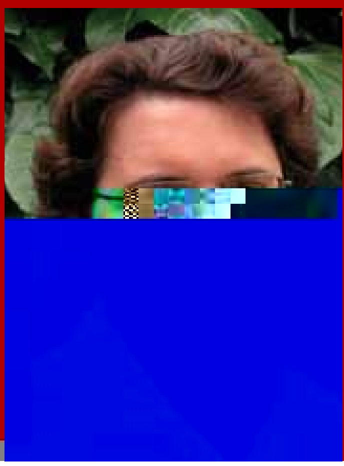
Norton says that some archivists were horrified that rare volumes were removed from storage and handled by others. But, she says, getting these unique books in the public eye is “the best thing in alJTJsidpal 803mchicente458.378T 512.368her 500.”

Discovering Nature's Codes

MBL Moment

with …

Nathan Wilson
Director, Biodiversity Informatics Group, Encyclopedia of Life
Director, MBL Center for Library and Informatics



I can combine my passion for nature and biology with my passion for computers and technology. It's the perfect job, says Nathan Wilson of his role as director of the Biodiversity Informatics Group for the Encyclopedia of Life (EOL). Wilson leads the MBL technical team that develops the software and hardware infrastructure for the EOL. He is also an avid field naturalist specializing in fungi (mushrooms). Wilson enjoys innovating with international collaborators in the growing field of biodiversity informatics, while at the same time delivering a high-quality product the EOL website to scientists and the general public.

Nathan Wilson is director of the MBL Center for Library and Informatics, where he oversees 12 informatics initiatives, including the EOL Biodiversity Informatics Group. While diverse, the Center's projects have the common goals of improved data management, data-driven discovery, and development of innovative visualization and analysis tools. Prior to coming to the MBL in 2010, Wilson worked for DreamWorks Animation for 12 years, where he focused on collaboration tools and open-source software. He was also active in the amateur mycology arena, serving as president of the Los Angeles Mycological Society. He has a master's degree in computer science from the University of California, Santa Cruz, and a master's degree in experimental psychology from the University of Pennsylvania.

MBL: **Which came first: your interest in nature and biology, or in computers?**

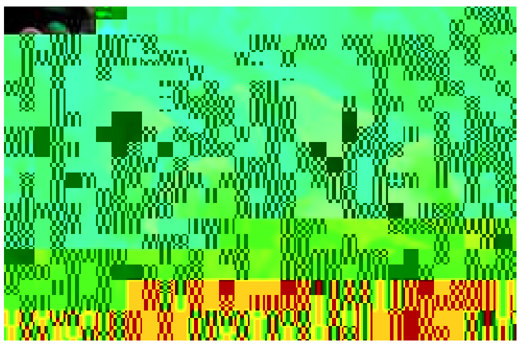
NW: I've been a naturalist since I could run out into the fields and collect frogs and snakes and butterflies. I got interested in mushrooms around age 10 and started reading books on mycology. In the seventh grade I became interested in computers, but I was sure I was going to be a biologist until my second year of college. Then I discovered that biology was primarily about chemistry at that time (early 1980s) and chemistry was my least favorite science. I ended up getting a master's degree in computer science, and my thesis was on identification of biological species using computers, with fungi as an example case.

Professionally, I focused on computers, working at SRI International, a couple of Silicon Valley startups, Apple Computer, Digital Domain, and most recently at DreamWorks Animation. While at DreamWorks, in my spare time I put together Mushroom Observer, which is a web site for people who study fungi. My goal was to organize the information on fungi in a collaborative way so people could work together to create a common picture of mycology. It's really grown; we now have more than 1,500 professional and amateur mycologists contributing from all over the world.

MBL: **What do scientists most value about the EOL, and what does the public most value?**

NW: Interestingly, what scientists say is most compelling is the EOL provides a vehicle for outreach. Many federal grants require that the scientist demonstrate the broader impacts of their research, and the EOL provides a public face and support for that. Scientists can just contribute their (species) information to the EOL and then it is part of a public resource that thousands of people visit on a regular basis.

The general public values the breadth of information in the EOL. As far as we know, we have data on more species than any other online system. Also, in contrast to a site like Wikipedia, they like that we clearly indicate the status and origin of the information. They know whether it has been vetted by scientists, either before coming to the EOL or through the EOL curatorial processes. Wikipedia has a similar review process, but it's less clear what the status of the information is. Also, in the EOL, we present the information in the scientists' own words in a way that it can't be changed. Unlike Wikipedia, we preserve the ability for a user to know, "What did this scientist actually say about this species?"



MBL: **What is the main challenge in the field of biodiversity informatics right now?**

NW: The main focus for biodiversity informatics is still the process of understanding how to bring all this species information together and have it make sense. There is a vast amount of data out there, only some of which we have tapped into with EOL. Several other groups besides the EOL are working on organizing the planet's species, and we are all working together to present that information. Different groups present different organizations of the tree of life, and EOL tries to remain agnostic on that by supporting multiple trees, multiple ways of organizing organisms. But how we manage those different organizations is a challenge.

MBL: **What does this mean for the EOL?**

NW: The challenge we have is our content can be confusing to users, because it's an assemblage of content that comes from many places. How do we present the information in a way that makes sense to most people, but also allows someone to drill down in a particular area? That is a key problem, and it is related to the more general problem of generating a more authoritative taxonomic classification for species.

Ultimately, what we need to do is enable the EOL curators to make more sense of the species pages. Right now, the EOL users rate content from 1 to 5, and the higher-rated content is presented on the page first. The content can also propagate up the tree and compete to be shown first, so the top image in the kingdom Animalia, for instance, will almost certainly have all ratings of 5. But we are working on giving the curators better tools for reviewing and improving content. So a curator might decide to present a good, brief summary of the organism first or a certain image first, maybe because it really characterizes that branch of the tree of life, even if it isn't the most popular image.

MBL: **As a side project, you are developing an alternative framework for naming organisms that groups them by observable traits, rather than by evolutionary relationships (taxonomy). Why is there a need for this?**

NW: Taxonomists are pursuing the question, "What are the self-propagating populations of organisms that we call species?" That is a really important question for a lot of reasons. For one, if I want to understand the preservation of biodiversity, and I don't know what is in a given population, I may kill off some group without even knowing that it was distinct. But there are also many important questions and socioeconomic issues related to organisms for which species classifications aren't relevant. For instance, if zebra mussels are imported to my region, what will be the impact on boat channels? I may not care that there are three species of zebra mussels, because there isn't any functional difference between them, from my perspective. I may only care what happens when zebra mussels are in my boat channels.

The system I'm working on is called the Semantic Vernacular Naming System. It is complementary to the traditional, scientific naming systems and shares many of the same features. It also uses some of latest computer science approaches to describing entities to create a practical, reliable way to describe and name meaningful groups of organisms. s —DK

Accolades

MBL Ecosystems Center director **Hugh Ducklow** was appointed to the U.S. Antarctic Program Blue Ribbon Panel. The 12-member panel, formed at the request of the White House Office of Science and Technology Policy and the National Science Foundation, is tasked with examining the status and capabilities of the U.S. Antarctic Program. Ducklow directs the Long Term Ecological Research Project at Palmer Station, on the west Antarctic Peninsula, a collaborative endeavor to study and understand the Antarctic marine ecosystem.

Ralph Brinster, an alumnus of the MBL FERGAP course (now Frontiers in Reproduction) was awarded the 2011 Presidential Medal of Science. Brinster, a professor at the University of Pennsylvania School of Veterinary Medicine, was honored for his research on the manipulation of the mammalian germline.

The **Census of Marine Life Scientific Steering Committee** was awarded Japan's International Cosmos Prize. **Researchers from the MBL's Bay Paul Center** were among the scientists contributing to the Census through their leadership of the International Census of Marine Microbes, a research project of the larger Census that focused on the biodiversity of microscopic life forms in the world's oceans.

MBL trustees recently elected six new Board members. **Dr.**

The Rise of VAMPS

Above: Each slice of the pie represents the abundance of a particular type of bacteria. VAMPS users can explore the data in each pie slice, such as individual DNA sequences.

Background: A global map of ICoMM sample locations. The origin of the samples is indicated by triangles (benthic or seafloor realm) and circles (pelagic or ocean water realm) while ecosystem types are indicated by the color orange (coastal), light blue (open-ocean surface waters), dark blue (deep sea), red (anoxic), and purple (hydrothermal vents). Further visualization of sample distributions are available at http://vamps.mbl.edu/mapper/index.php.

When scientists began collecting tens of thousands of genetic sequences for the International Census of Marine Microbes (ICoMM), the project's co-director, MBL microbiologist Mitchell Sogin, knew they would need better software to handle all that data. So he oversaw the development of a free online tool called Visualization and Analysis of Microbial Population Structures (VAMPS).

VAMPS allows scientists to upload microbial genetic sequences, interpret what kinds of microbes harbor those sequences, and use sophisticated paradigms to compare the microbial communities represented by the sequences as comprehensive charts and color-coded graphs. The website is distinctive in many ways, but is particularly unique in allowing scientists to easily convert between taxonomic levels—phylum, family, genus, etc.

"You can really control at what level the analyses are being done," Sogin says. "You don't see that in other software."

VAMPS also links maps of ICoMM's ocean sampling locations to metadata (temperature, salinity, pH, geospatial and temporal information). In addition, it links to external websites such as GenBank and the Encyclopedia of Life, which provide details about particular species. And Sogin and colleagues, including the MBL's David Mark Welch and Susan Huse, continue to develop increasingly sophisticated tools for VAMPS users.

These days, VAMPS users still include ICoMM scientists. But it is now also a vital tool for other projects, including the Microbiology of the Built Environment Network and the Deep Carbon Observatory, which examines microbes deep inside the earth. As of early this year, VAMPS had more than 750 registered users from around the world.

"VAMPS can be used for any molecular microbial ecology project," Sogin says. "It's becoming very popular." s —SES

A DIVERSITY OF FISHES

The voyage of *L'Astrolabe* (1826-29) was a scientific expedition to the South Pacific under the command of French explorer and naval officer Jules-Sébastien-César Dumont d'Urville. The explorers brought back hundreds of plant specimens, rock samples, and a wealth of observations, which were published in 31 volumes by J. Tastu and Ministère de la Marine of the French government. The books contain finely detailed illustrations of terrestrial and aquatic organisms that showcase the biodiversity the explorers encountered, as well as maps, charts, and other scenes of discovery.

These hand-colored fishes were rendered by scientific illustrators who accompanied the voyages to record their discoveries. The fishes are described as (top to bottom): "*Comphose Bleu, Malacanthe Ray , Girelle a front Bomb ,* and *Aspidonte a Ruban.*" s—MP

From *Voyage de la Corvette l'Astrolabe: Ex cut par Ordre du Roi, Pendant les Ann es 1826-1827-1828-1829, sous le Commandement de J. Dumont d'Urville* (Paris: J. Tastu and Ministère de la Marine, 1830-1834), Plate 19.

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In the Next MBL *Catalyst*

Neuroscience U

What are the biggest discoveries and mysteries in neuroscience today? The MBL is the place to find out. Our campus becomes "Neuroscience Central" during the summer, thanks to a convergence of hundreds of the world's top researchers, faculty, and students in this exciting and rapidly advancing field.